Memo

Date:	Monday, May 08, 2017
Project:	Henderson Branch Sanitary Sewer Extension
To:	David Sorrell, PE; Erin Keys, PE
From:	Aaron Bresette, PE, Trent Stober, PE
Subject:	Pump Station Alternative

HDR has developed preliminary plans to construct a sanitary sewer to serve existing and future growth in the 1,300 acre Henderson Branch Watershed by gravity. The proposed gravity sewer would also serve several existing subdivisions west of the Henderson Branch Watershed served by Boone County Regional Sewer District (BCRSD). Preliminary design information is included in HDR's November 2015 Memorandum titled "City of Columbia, Missouri Design Criteria for Henderson Branch Sewer Extension" (Design Criteria).

Topographic survey, subsurface geotechnical investigations, and preliminary design for the sewer were completed in 2016. The preliminary gravity sewer alignment extends from an existing Perche Creek Interceptor manhole on the west side of Perche Creek near the Henderson Branch to a point north of I-70 near the Midway Auto Truck Plaza at the NW corner of the I-70 and M-40 interchange. The proposed service area for the gravity sewer includes Areas 1 through 4 as shown in Figure 1.

The sewer will be owned and maintained by the City of Columbia. The proposed alignment includes an approximate total of 8,645 LF of 24-inch and 30-inch PVC pipe. Due to the presence of unstable soils with probable high groundwater conditions in the lower portion of the sewer alignment near Perche Creek, construction costs are estimated to be higher than the amount budgeted in 2015.

As an alternative, the City requested HDR prepare feasibility and cost evaluation to construct a pump station at a location between Van Horn Tavern Road and the Henderson Branch Creek, south of the Boone County Regional Sewer Districts' wastewater treatment facility at Midway Arms. From the pump station, a force main would convey flow southeast to the Perche Creek Interceptor. The pump station and force main would be constructed in lieu of approximately 4,410 linear feet of 30-inch gravity sewer at the lower end of the watershed, in the area where pipe would be deepest and encounter the most unstable soil conditions. The force main option would be constructed much shallower, at 48-inch minimum bury depth, reducing the construction cost of deeper gravity sewer through the most challenging conditions. The alignment of the force main would approximate the alignment of the proposed gravity sewer. The 4,235 LF of gravity sewer upstream of the pump station would be constructed as originally proposed.

The pump station would serve the upper portions of the service area which includes Areas 1, 2, and 3 shown on Figure 1. Area 4 would not be served by this project without additional gravity sewer being installed, discharging to the new pump station or the Perche Creek interceptor.

Pump Station and Force Main Design Flow Assumptions

Due to the wide variation between existing flow and ultimate flow in the watershed, we recommend that the pump station be designed and constructed in Phases as growth occurs and peak flow rates are better known.

The Phase 1 pump station would serve developed areas identified on Figure 1. The area includes three fully developed subdivisions known as Trails West, Rollingwood, and Midway Crossing currently served by BCRSD wastewater treatment facilities. It would serve another BCRSD facility currently treating wastewater from Midway Arms. In addition, the pump station would serve Midway Truck Plaza currently utilizing a private treatment lagoon. The remainder of the service area is currently undeveloped or consists of large acreage single family residences served by private septic systems.

Flow assumptions used to size the pump station for the initial condition are summarized in Table 1.

Table 1 - Phase 1 Projected Initial Flow

Service Area	Annual Average Daily Flow (gpd)	Daily Peak Hourly Flow @ 4x Annual Avg. (gpd)	Wet Weather Peak Flow @ 10x Annual Avg. (gpd)
Trails West	29,800	119,200	298,000
Midway Crossing	11,300	45,100	112,800
Rollingwood	400	1,700	4,200
Midway Auto. Truck Plaza	44,700	178,900	447,200
Midway Arms	2,000	7,800	19,500
Total	**88,200**	**352,700**	**881,700**

The following peaking factors have been applied:

- Peak hour dry weather flow is four times the annual average flow. This is consistent with MDNR minimum design standards.
- Due to the age and unknown condition of the collection system, peak wet weather design flow is set at ten times the annual average flow. This is extrapolated for the existing condition from the total peak flow calculation for Area 1 and 2 from the November 2015 Design Criteria Memorandum.

Pump Station Assumptions

- The pump station would be constructed in phases. Phase 1 would accommodate initial conditions as described above and allow for development growth within the service area.
- While the initial wet weather peak flow is estimated to be 0.88 MGD (612 gpm), two 1.73 MGD (1,000 gpm) pumps would be installed in Phase 1. The pumps would be controlled by variable frequency drives (VFD). Initial pump speeds would be reduced by the VFD to better match the existing condition.

- As growth occurs, typical pump run speeds would increase to accommodate the added flow. In total, Phase 1 will allow for growth of approximately two times the existing or initial flow.
- Phase 1 design allows for doubling the existing peak flow condition with one pump running. As new sewers are constructed, peaking factors may be lower than assumed because new pipe construction should have a lower level of infiltration and inflow into the system.
- Utility electrical service would be sized to allow for both pumps to operate simultaneously.
- To back up utility power, a generator and manual transfer switch would be provided. The generator would be sized to operate both pumps simultaneously.
- The wet well would be constructed of 8 foot diameter pre-cast concrete pipe sections. The depth would be approximately 28 foot.
- Until growth occurs, long detention times in the wet well between pump cycles would be likely. This creates a high potential for hydrogen sulfide generation during dry weather conditions. The wet well would be epoxy lined to minimize corrosion. Odor control was not included in the cost estimate.
- A separate valve vault would be constructed adjacent to the pump station.
- The wet well size will accommodate the larger pumps anticipated in Phase 2.
- A 6 foot chain link fence and 12 foot gate would be provided.
- Due to the topography, the high point of the force main would be at the pump station valve vault. It is anticipated the force main would drain by gravity when a pump shuts off, thus an air vacuum relief valve would be installed in the valve vault.
- Grit settlement would be minimal because the force main would drain by gravity each time the pumps cycle.
- City owned equipment has sufficient capacity to remove pumps from the wet well, no jib crane is assumed.
- No water service would be provided to the site.

Force Main Assumptions

- The force main diameter would be sized for a minimum velocity of 2.45 Ft/sec at the initial design flow of 612 gpm, and 4.09 ft/sec at the Phase 1 design maximum flow (1,000 gpm).
- Phase 2 would increase the maximum flow to 2,000 gpm where the velocity would rise to 8.0 ft/sec.
- A 10-inch diameter force main pipe is anticipated to meet these conditions for Phase 1 and Phase 2.
- The force main pipe material would PVC.
- The force main would be installed with a minimum of 48-inch of cover.
- The force main alignment would approximately follow the preliminary gravity sewer design alignment. Easements would be purchased as per the gravity sewer design.
- A permanent easement would be purchased for the pump station site.
- The length would be approximately 4,640 feet.

Pump Station Phase 2

When the Phase 1 pump station has reached its capacity as described above, the station would require modifications referred to as Phase 2. It is anticipated that Phase 2 would require replacement of the pumps and VFDs. The two Phase 1 pumps (1,000 gpm) would be replaced with two 2,000 gpm pumps,

doubling the capacity of Phase 1. In total, Phase 1 and Phase 2 would allow for growth of approximately 3.3 times the existing or initial flow. The electrical utility service and the generator would require upsizing as part of Phase 2 improvements. However, the Phase 1 wet well and force main are sized to accommodate Phase 2 pumps and flow respectively. For pricing comparisons it is assumed Phase 2 pump station upgrade will occur in year 30 after initial Phase 1 construction.

To allow for growth beyond the capacity of the Phase 2 pump station, Phase 3 would require a second pump station to be constructed adjacent to the original pump station as the wet well will be inadequately sized to accommodate larger or more pumps. In addition, a second force main would be installed parallel to the original to accommodate the increased flow. An alternative to the Phase 3 pump station improvements would be to decommission the Phase 2 pump station and force main and construct the remainder of the gravity sewer downstream of the pump station to the Perche Creek Interceptor.

Alternatives Cost Comparison

Construction cost estimates for the pump station alternative was calculated to compare to the original full gravity sewer alternative (Alternative 1). All initial cost estimates were calculated utilizing 2016 dollars. Future year capital costs have been escalated based on the long term Average Annual Inflation rate for the last 30 years, 2.8%, compounded yearly. A summary of the Capital Cost Comparison is shown in Table 2. This comparison shows the capital investment required for each Alternate but does not account for periodic operation and maintenance expenses. Furthermore, these cost estimates compare capital expenditures at a specific moment in time and do not account for the time value of money. Money that is available now is inherently more valuable than the same amount in the future, because that money could be used as capital for an investment that earns interest. As a result, capital that is available in the future is "discounted". *Discount rates for Cost-Effectiveness Analysis of Federal Programs* are published by the Office of Management and Budget in the Federal Register on a yearly basis. The Discount Rate used for long term cost analyses are based on nominal interest rates on 30-year U.S. Treasury Notes and Bonds.

A Net Present Value (NPV) analysis can be performed to determine the present amount of money needed for all payments and provides a basis of comparison for projects with different payment schedules but similar lifetimes. A NPV analysis accounts for the inflation of future costs while also discounting those future costs assuming the required money is available present day and placed in an investment with returns equivalent to a 30-year Treasury Note. A project NPV comparison has been prepared to compare total upfront capital costs, annual O&M costs, and future capital costs to provide additional capacity. A summary of the NPV Cost Comparison is shown in Table 3.

NPV Assumptions:

- 2016 base year
- 2019 Construction complete
- 90 year study period (2020-2110)
- 30-year nominal interest rate, 2.8%*
- 30-year real discount interest rate, 0.7%*
- Gravity sewer O&M costs, $0.995/LF/year
- Pump station O&M costs

- Labor: 1 person @ $25/hr. plus 1 vehicle @ $14/hr., 1 hr./day, 5 days/week
- Operations: electricity @ $0.065/kW-hr

* per Federal Register / Vol. 82, No. 6 / Tuesday, January 10, 2017

Summary of Alternatives Compared:

1. Original 8,645 LF of 30-inch and 24-inch gravity sewer, sized for the watershed's ultimate development
   - 90 year life
   - O&M costs beginning in year 5 after completion and continuing annually
2. Gravity sewer for the upper 4,235 LF with a Pump Station and 4,410 LF of force main
   - Phase 1 Pump Station, 30 year life
   - Phase 2 Pump Station, pump replacement/upsize in year 30, 30 year additional life
   - Phase 3 Pump Station and force main improvements in year 60, 30 year additional life
3. Gravity sewer for the upper 4,235 LF with a Pump Station and 4,410 LF of force main
   - Phase 1 Pump Station, 30 year life span
   - Phase 2 Pump Station pump replacement/upsize in year 30, 30 year additional life span
   - Year 60 – Pump Station and force main decommissioned and remaining 4,410 LF of gravity sewer constructed

Table 2 - Alternative Capital Cost Comparison

	Alternate 1 Full Gravity	**Alternate 2 Upstream Gravity w/ PS and Force Main**	**Alternate 3 Upstream Gravity w/ PS and Force Main Complete Gravity in Yr. 60**
Initial Capital Cost (2016 $)	$4,234,000.00	$3,140,000.00	$3,140,000.00
Phase 2 Pump Replacement / Upsizing (2049 $)		$773,000.00	$773,000.00
Phase 3 Pump Station & Force Main (2079 $)		$6,038,000.00	
Pump Station/Force Main Decommission and Gravity Sewer (2079 $)			$9,595,000.00
Total Capital Expenditure	**$4,234,000.00**	**$9,951,000.00**	**$13,508,000.00**

Table 3 - NPV Cost Comparison

	Alternate 1 Full Gravity	**Alternate 2 Upstream Gravity w/ PS and Force Main**	**Alternate 3 Upstream Gravity w/ PS and Force Main Complete Gravity in Yr. 60**
NPV Initial Capital Cost	$4,150,000.00	$3,080,000.00	$3,080,000.00
NPV of 90 Year O&M Cost	$530,000.00	$1,300,000.00	$1,070,000.00
NPV of Future Capital Cost	$0.00	$940,000.00	$1,350,000.00
Total 90 Year NPV	**$4,680,000.00**	**$5,320,000.00**	**$5,500,000.00**